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FINAL GROUNDWATER MONITORING REPORT JANUARY-FEBRUARY 2003

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
JET PROPULSION LABORATORY
4800 Oak Grove Drive
Pasadena, California 91109

Contract No. N68711-01-D-6008

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LIST OF ACRONYMS AND ABBREVIATIONS

1,1-DCA	1,1-Dichloroethane
1,2-DCA	1,2-Dichloroethane
1,1-DCE	1,1-Dichloroethene
APCL	Applied Physics and Chemistry Laboratory
ASTM	American Society for Testing and Materials
CCl_4	Carbon Tetrachloride
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
ClO_4^-	Perchlorate
Cr	Chromium
Cr (VI)	Hexavalent Chromium
DLR	Detection Limit for the Purposes of Reporting
DQOs	Data Quality Objectives
DTSC	Department of Toxic Substance Control
EPA	Environmental Protection Agency
Geofon	GEOFON, Inc.
gpm	Gallons per minute
IAL	Interim Action Level
JPL	Jet Propulsion Laboratory
LDC	Laboratory Data Consultants, Inc.
MCLs	Maximum Contaminant Levels
μg/L	Micrograms per Liter
mg/L	Milligrams per Liter
mL	Milliliter
MS	Matrix Spikes
MSD	Matrix Spike Duplicates
MW	Monitoring Well
NASA	National Aeronautics and Space Administration
OU	Operable Unit
PCE	Tetrachloroethene
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RWQCB	California Regional Water Quality Control Board
SOTA	SOTA Environmental Technology, Inc.
SWDIV	Naval Facilities Engineering Command, Southwest Division
TCE	Trichloroethene

LIST OF ACRONYMS AND ABBREVIATIONS (CONTINUED)

USEPA	United States Environmental Protection Agency
VOCs	Volatile Organic Compounds
Westbay	Westbay Instruments, Inc.

EXECUTIVE SUMMARY

This report presents the results of the January-February 2003 groundwater sampling event completed as part of the groundwater monitoring program at the National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory (JPL) under contract with Naval Facilities Engineering Command, Southwest Division. This sampling event was conducted from January 27 through February 26, 2003.

During this sampling event, groundwater samples were collected from 23 JPL monitoring wells, both on- and off-facility, and analyzed for volatile organic compounds (VOCs), metals (total chromium and hexavalent chromium), and perchlorate.

All data collected were subject to data verification and laboratory analytical data were validated pursuant to the Navy's Level III and Level IV quality assurance requirements. Some of the analytical data were qualified based on data validation reviews, in accordance with applicable U.S. EPA guidelines. No data were rejected for non-compliance with method requirements during the course of validation and no data were qualified as unusable. The analytical results are summarized below.

- Seven on-facility wells and four off-facility wells contained concentrations of one or more of four VOCs (carbon tetrachloride, trichloroethene, tetrachloroethene, and 1,1-dichloroethene), that exceeded State or Federal Maximum Contaminant Levels (MCLs) for drinking water. Concentration contour maps generally indicate slow migration of the contaminant plumes over the last year.
- Perchlorate was detected in twelve on-facility wells and three off-facility wells, with concentrations in five on-facility wells and 3 off-facility wells that exceeded the State Interim Action Level (IAL). Perchlorate concentrations in the three most highly contaminated wells have generally decreased in this sampling period compared to the results collected over the last couple of years. Concentration contour maps generally indicate slow migration of the contaminant plume over the last year.
- Total chromium was detected in twenty wells, with concentrations at one on-facility well that exceeded the State and Federal MCL. Hexavalent chromium was detected in one well. At this time, neither State nor Federal regulatory agencies have established MCLs for hexavalent chromium.

Groundwater gradients and flow directions before and after sampling activities were consistent with previous observations. Moderate increases in hydraulic head were measured in shallow wells and Westbay well screens in Aquifer Layers 1, 2, and 4, while significant increases were measured in Aquifer Layer 3 well screens. The water level fluctuations are likely due to several hydrologic phenomena operating simultaneously including, but not limited to, groundwater recharge, pumpage, and/or artificial recharge.

1.0 INTRODUCTION

GEOFON Inc., (Geofon) has been retained by the U.S. Navy, Naval Facilities Engineering Command, Southwest Division (SWDIV) to implement the Groundwater Monitoring Program currently being conducted at the National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory (JPL). This report summarizes the results from the January-February 2003 groundwater sampling event. This work is being performed by Geofon under contract with Naval Facilities Engineering Command, Contract No. N68711-01-D-6008 D.O. No. 0001.

The JPL Monitoring Program was initiated in 1996 in response to a request from the United States Environmental Protection Agency (USEPA). The program began during the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Remedial Investigation of on-facility and off-facility groundwater at JPL. The purpose of the program is to monitor the elevation, flow direction, and quality of the groundwater beneath and adjacent to the JPL site.

The locations of the JPL groundwater monitoring wells are shown in Figure 1-1. Monitoring wells MW-3, MW-4, MW-11, MW-12, MW-14, and MW-17 through MW-24 are deep multi-port wells, each containing five screened intervals equipped with a Westbay Instruments, Inc. (Westbay) multi-port casing system. Monitoring wells MW-5, MW-6, MW-8, MW-10, MW-13, and MW-16 are relatively shallow standpipe wells, each containing a single screened interval located just below the water table. A summary of the well construction details for the JPL groundwater monitoring wells is included in Table 1-1.

During the January 2003 event, Geofon collected samples from all JPL monitoring wells except on-facility wells MW-1, MW-2, MW-9, and MW-15. Shallow well MW-2 has not been sampled since it was replaced with deep multi-port well MW-14 as a JPL sampling point. Wells MW-1, MW-9, and MW-15 were not sampled during this event in accordance with the sampling program that was previously approved by the EPA, DTSC, and RWQCB.

In addition, the water-level elevation at each well was measured on January 27 and 28, 2003 (prior to sampling), and on February 26, 2003 (after sampling) to evaluate groundwater flow directions and gradients.

Samples from each well were collected and analyzed during this event in accordance with the sampling program that was approved by the Environmental Protection Agency (EPA), Department of Toxic Substance Control (DTSC), and California Regional Water Quality Control Board (RWQCB).

All of the JPL groundwater samples were shipped to Applied Physics and Chemistry Laboratory (APCL) in Chino, California, for chemical analysis. APCL is certified by the California Department of Health Services and approved for use by the Naval Facilities Engineering Command, Quality Assurance/Quality Control (QA/QC) program. Sample collection procedures and sample analysis were conducted by Geofon in accordance with the Work Plan for Performing a Remedial Investigation/Feasibility Study (Ebasco, 1993a), approved by the regulatory agencies.

In addition to groundwater samples, field quality assurance/quality control (QA/QC) samples, including trip blanks, equipment blanks, duplicate samples, and a field blank were collected for laboratory analyses. Sampling records for each shallow well and field data sheets for deep multi-port wells are included in Appendix A. Piezometric pressure profiling records for each deep multi-port well are included in Appendix B. Laboratory analytical reports and associated chain-of-custody forms are included in Appendix C, and data validation reports are provided in Appendix D.

Appendices E and F present summaries of analytical results for volatile organic compounds (VOCs) and metals, respectively, that were reported by others prior to GEOFON's initiation of the Long-Term Groundwater Monitoring activities at the JPL facility in January of 2003. Due to Navy's request, the format of the tables summarizing the result of the groundwater sample parameters was modified by GEOFON to present the data qualifiers as reported by the data validation company.

2.0 FIELD SAMPLING PROCEDURES

Two different procedures were used to collect of groundwater samples at JPL, one designed for the shallow wells and the other for the deep multi-port wells. These procedures are outlined below.

2.1 Shallow Monitoring Wells

The sampling procedure described below was applied to all the shallow JPL monitoring wells, including MW-5, MW-6, MW-8, MW-10, MW-13, and MW-16.

The primary equipment used to sample the shallow wells included dedicated 2-inch diameter Grundfos Redi-Flo2® pumps, a pump controller, and a 220-volt generator. All of the dedicated Grundfos Redi-Flo2® pump systems were previously decontaminated prior to their permanent installation. Details of the decontamination procedures for the Grundfos Redi-Flo2® pump systems are outlined in the OU-1 Field Sampling and Analysis Plan (Ebasco, 1993b).

Prior to sample collection, the water in each shallow well casing was purged (by pumping at about 2.5 gpm) to remove groundwater that may have been exposed to the atmosphere and thus may not be representative of undisturbed aquifer conditions. This purged groundwater was discharged into 500 or 1,000-gallon polyethylene storage tanks for subsequent disposal by Geofon in accordance with Federal, State, and local regulations.

Temperature, pH, electrical conductivity, and turbidity of the water removed from each well were monitored during purging. Pursuant to the approved work plan (Ebasco, 1993b), a minimum of three casing volumes of water was purged and temperature, pH, electrical conductivity and turbidity were monitored for stabilization. When two successive measurements made approximately 5 minutes apart were within 10 percent of each other, groundwater samples were collected using the dedicated pump. During sampling for VOCs, the pumping rate was reduced to minimize sample agitation and volatilization. All information concerning sampling was noted on the Well Development/Well Sampling Log forms included in Appendix A.

All sample bottles were filled completely without overflowing, capped, labeled, and immediately placed in a cooler with ice. Samples collected for VOCs had zero headspace.

Calibration, or standardization of the field instruments used to measure temperature, pH, electrical conductivity, and turbidity, was performed according to the manufacturer's specifications at the beginning of each sampling day.

A groundwater sample was collected from shallow well MW-8 on February 24, 2003. The sampling procedure for this well was generally the same as for the other shallow wells, with the following exception:

A 2" diameter submersible Grundfos pump was temporarily installed at well MW-8, which was used for purging and sampling at MW-8.

2.2 Deep Multi-Port Monitoring Wells

Sampling of the deep multi-port monitoring wells at JPL required specialized sampling equipment manufactured by Westbay. This equipment included a pressure profiling/sampling probe with a surface control unit. To ensure proper use, field personnel using this equipment were trained by Westbay personnel. Copies of the detailed operations manuals for the Westbay pressure profiling/sampling probe are included in the OU-1 and OU-3 Field Sampling and Analysis Plans (Ebasco, 1993b; 1994).

The Westbay sampling probe and sample-collection bottles were decontaminated prior to sampling each screened interval in the deep multi-port wells according to the following procedures:

- Each 250-mL stainless-steel sample-collection bottle was washed in a solution of non-phosphate detergent (Liquinox®) and distilled water, followed by a solution of an acidic detergent (Citranox®) and distilled water.
- Each bottle was rinsed with distilled water.
- The interior surfaces of the Westbay sampling probe, and the hoses and valves associated with the Westbay sample bottles were decontaminated by forcing several volumes of a solution of Liquinox® and distilled water through them, followed by forcing several volumes of a solution of Citranox® and distilled water. A final rinse with distilled water was carried out. Each of these decontamination procedures was completed using clean plastic spray bottles used only for this purpose.

Purging before sampling is not required in the deep multi-port monitoring wells because the groundwater sample was collected directly from the aquifer, thus ensuring that the groundwater sample was not exposed to the atmosphere. However, at each screened interval, an initial sample was collected in order to check temperature, pH, electrical conductivity, and turbidity in the field. Samples for laboratory analysis were then collected and transferred to sample containers as described in Section 2.1. Results of the field analyses were recorded on groundwater sampling field data sheets, which are included in Appendix A. Calibration of field instruments was carried out according to procedures described previously.

2.3 Field Quality Assurance/Quality Control Samples

Field QA/QC samples were collected to verify the quality of sampling procedures. The field QA/QC program included the collection of duplicate samples, equipment blanks, trip blanks, and source blanks. Laboratory QA/QC samples were used by the laboratory according to analytical method requirements.

Duplicate samples for VOCs, metals, and perchlorate (ClO4–) analyses were collected from shallow groundwater monitoring well MW-7, and deep multi-port monitoring wells MW-12 (Screen 2), MW-14 (Screen 4), MW-19 (Screen 4), MW-20 (Screen 1), and MW-22 (Screen 2).

Matrix-Spike (MS) and Matrix-Spike Duplicate (MSD) samples were collected for 10% of samples that were analyzed for VOCs, perchlorate, and metals (total and hexavalent chromium). These samples were used for laboratory QA/QC requirements.

One equipment blank was collected from the Westbay sample-collection bottles during each day of sampling the deep multi-port wells. Equipment blanks consisted of distilled water that was passed through the sampling equipment after the equipment was decontaminated. Equipment blanks were analyzed for the same constituents as the groundwater samples, except for cations and anions, total dissolved solids, and pH, to identify potential cross contamination due to inadequate decontamination. Because only dedicated sampling equipment was used, equipment blanks were not collected during sampling of the shallow wells.

A trip blank, consisting of ASTM Type II water placed in two 40-mL glass vials by the laboratory, was transported with the empty sample bottles to the field and back to the laboratory with the groundwater samples. One trip blank was submitted for VOC analysis with each shipment of groundwater samples to the laboratory. Trip blanks were used to identify potential cross contamination of groundwater samples during transport.

During this sampling event, one source blank was collected on January 29th. The source blank was used to evaluate whether the source water or sample containers may have affected the analytical results. The source blanks, consisting of sample bottles filled with distilled water, were analyzed for VOCs.

3.0 ANALYTICAL RESULTS

The groundwater samples collected during this sampling event were analyzed for the following:

- Volatile Organic Compounds
- Total Chromium (Cr)
- Hexavalent Chromium [Cr(VI)]
- Perchlorate ($ClO4^-$)

A summary of the samples collected and the analyses performed on each sample is presented in Table 3-1. Analytical laboratory reports and associated chain-of-custody forms are included in Appendix C.

The aquifer beneath JPL was divided into four aquifer layers based primarily on correlations interpreted from lithologic cross sections (Foster Wheeler, 2000). Table 3-2 provides a list of the JPL Westbay monitoring well screens and their corresponding aquifer layers. Concentrations of carbon tetrachloride (CCl4), trichloroethene (TCE), tetrachloroethene (PCE), and ClO4– reported during this event are presented for each aquifer layer in Figures 3-1 through 3-12.

3.1 Volatile Organic Compounds

Groundwater samples collected during the January-February 2003 sampling event were analyzed for over 60 different VOCs in accordance with EPA Method 524.2. Results of the analyses for VOCs in the January-February 2003 samples are summarized in Table 3-3 along with the State and Federal Maximum Contaminant Levels (MCLs) for drinking water as listed in Title 22 of the California Code of Regulations and in the EPA Health Advisory Guidelines.

A small number of compounds were detected in the JPL samples, and four VOCs [carbon tetrachloride, TCE, PCE, and 1,1-DCE] were found in one or more wells at concentrations that exceeded State and/or Federal MCLs. The concentrations of carbon tetrachloride, TCE, and PCE detected in each aquifer layer were contoured on site maps to show the spatial distribution of each constituent (Figures 3-1 through 3-9). The analytical results for compounds that exceeded MCLs are discussed below.

- Concentrations of carbon tetrachloride in excess of the State MCL (0.5 µg/L) were reported in samples from seven on-facility wells (MW-5, MW-7, MW-8, MW-12, MW-13, , MW-16, and MW-24) and two off-facility wells (MW-17 and MW-18). The Federal MCL (5.0 µg/L) was exceeded in all of these wells, except MW-5, MW-8, and MW-12. The highest concentrations of carbon tetrachloride were reported in well MW-7 (122 µg/l) and well MW-17 (13.1 µg/l).

- Trichloroethene was detected in eleven on-facility wells and five off-facility wells. Reported TCE concentrations exceeded the State and Federal MCL (5.0 µg/L) in one on-facility well (MW-14) and one off-facility well (MW-5). The highest concentrations of TCE were reported in samples from on-facility wells MW-5 (14.9 µg/L) and MW-14 (6.2 µg/L).
- Tetrachloroethene was detected in nine on-facility wells and in five off-facility wells. The State and Federal MCL (5.0 µg/L) was exceeded only in off-facility well MW-21 (9.6 µg/L in Screen 5) and on-facility well MW-7 (13.5 µg/L).
- 1,1-Dichloroethene was detected in three on-facility wells (MW-6, MW-7, and MW-24 Screen 1), with one concentration reported at the 6.4 µg/L (MW-7) and the remaining concentrations reported between 0.5 and 0.7 µg/L.

A summary of the VOC results compiled from the long-term sampling events that have been completed prior January 2003 is provided in Appendix E. Nine chemicals have been most commonly reported with concentrations above the laboratory detection limits [CCl4, TCE, PCE, 1,1-dichloroethane (1,1-DCA), 1,2-dichloroethane (1,2-DCA), 1,1-dichloroethene (1,1-DCE), Freon 113, Chloroform, and ClO4–)]. The concentrations of these compounds versus time were plotted, if at any time they exceeded their respective MCL in the period from August/September 1996 through January-February 2003. The plots are presented in Figures 3-13 through 3-54.

Additional data regarding VOC concentrations in samples collected from the 15 municipal production wells in the vicinity of JPL was obtained from the California Department of Health Services Drinking Water Program. The most recently available analytical results were compiled for samples collected from municipal and private drinking water wells owned and operated by the City of Pasadena, La Canada Irrigation District, Lincoln Ave. Water Company, Valley Water Company, Rubio Canon Land & Water Company, and Las Flores Water Company. The drinking water data are summarized in Table 3-4 and presented in the concentration contour maps for carbon tetrachloride, PCE, and TCE in Figures 3-1 through 3-9.

The most recent samples from two drinking water wells exceeded the State MCLs for carbon tetrachloride and PCE. TCE was detected in City of Pasadena, Lincoln Ave. Water Co., and Valley Water Co. wells, (with the exception of Well #2) but was not reported above the MCL (5.0 µg/L) at any of these locations. PCE was detected in nine of the 15 municipal wells, exceeding the MCL (5.0 µg/L) at Las Flores Water Co. Well #2 (11 µg/L). Carbon tetrachloride was detected in one municipal well (City of Pasadena Well #52) at concentration of 0.6 µg/L, which is above the State MCL of 0.5 µg/L.

3.2 Perchlorate

Perchlorate (ClO4–) analyses were conducted on groundwater samples from the January-February 2003 event using ion chromatography (EPA 314.0, modified) and the results are summarized in Table 3-3. No MCLs have been established for perchlorate, although the California Department of Health Services has established an IAL of 18 μg/L. The Detection Limit for the Purpose of Reporting (DLR) is established at 4 μg/L. Perchlorate was detected in twelve on-facility wells and three off-facility wells. Perchlorate concentrations in six on-facility wells exceeded the IAL (MW-5, MW-7, MW-8, MW-13, MW-16, and MW-24).

The highest levels of perchlorate were reported in samples from MW-7 (6,190 μg/l in duplicate sample), MW-17 (145 μg/l in screen 3), and MW-24 (257 μg/l in Screen 1). Perchlorate concentrations in these farthest upgradient wells have generally increased over the last two years, which suggests that the source is nearby or to the north. Perchlorate concentrations have been contoured in Figures 3-10, 3-11, and 3-12 for aquifer layers 1, 2, and 3, respectively.

Additional data regarding perchlorate concentrations in samples collected from the fifteen municipal production wells in the vicinity of JPL was obtained from the California Department of Health Services Drinking Water Program. The most recently available analytical results were compiled for samples collected from municipal and private drinking water wells owned and operated by the City of Pasadena, La Canada Irrigation District, Lincoln Ave. Water Company, Valley Water Company, Rubio Canon Land & Water Company, and Las Flores Water Company. The drinking water data are summarized in Table 3-4 and presented in the concentration contour map in Figure 3-10. Perchlorate did not exceed the IAL (18 μg/L) in any of the off-facility wells. The highest concentration of perchlorate was detected in Well 52 at 10.5 μg/L. Perchlorate was detected in six of the fifteen off-facility wells.

3.3 Metals

Groundwater samples collected during the January-February 2003 event were analyzed for the following metals: total chromium and hexavalent chromium. The results of the metals analyses are presented in Table 3-5, and are summarized below.

- Total chromium was detected in twenty wells in eleven on-facility wells and nine off-facility wells. Total chromium concentrations in on-facility well MW-13 (0.09 mg/L) exceeded the State MCL (0.05 mg/L).
- Hexavalent chromium was detected in two on-facility wells, MW-13, at a concentration of 0.055 mg/L and MW-16 at a concentration of 0.020 mg/L. At this time, neither State nor Federal regulatory agencies have established MCLs for hexavalent chromium.

Appendix F presents a summary of metals data from all quarterly sampling events completed prior to January 2003.

3.4 Quality Assurance/Quality Control

Review of the QA/QC data provided with the laboratory analytical results indicates that all of the analytical results obtained from January-February 2003 samples are acceptable for their intended use of characterizing aquifer quality. Surrogate compound, matrix and blank spike, and method blank results were used by the laboratory to determine the accuracy and precision of the analytical techniques with respect to the JPL groundwater matrix, and to identify anomalous results due to laboratory contamination or instrument malfunction. In addition to laboratory QA/QC samples, Geofon personnel collected QA/QC samples in the field in general accordance with Quality Assurance Project Plan (QAPP) (Ebasco, 1993c). The field QA/QC samples included duplicate samples, equipment rinsate blanks, trip blanks, and a source blank.

Duplicate samples were used to evaluate the precision of the laboratory analyses. Duplicate samples for VOCs, metals, and perchlorate (ClO_4^-) analyses were collected from shallow groundwater monitoring well MW-7, and deep multi-port monitoring wells MW-12 (Screen 2), MW-14 (Screen 4), MW-19 (Screen 4), MW-20 (Screen 1), and MW-22 (Screen 2). All of the analytical results for the duplicate samples were comparable to the results of the original groundwater samples (Table 3-3 and Table 3-5).

Equipment rinsate blanks were collected each day non-dedicated sampling equipment was used. A total of 10 equipment rinsate blanks were collected during this sampling event. The equipment rinsate blanks, consisting of distilled water run through the sampling equipment after decontamination, were analyzed for all contaminants of concern to monitor possible cross-contamination of samples due to inadequate decontamination. Toluene, 1,3-Dichloropropane, Chloroform, and/or 2-Butanone were detected in six equipment rinsate blanks (EB-1, EB-3, and EB-5 through EB-8) at trace concentrations (i.e., at or near the practical quantitation limit). Table 3-6 presents a summary of contaminants detected in quality control samples collected during the January-February 2003 sampling event.

A laboratory-prepared trip blank, consisting of reagent-grade water placed in VOA vials and transported with the sample bottles to the field, was submitted to the laboratory with each daily shipment of groundwater samples. Trip blanks were used to help identify cross-contamination of groundwater samples during transport and/or deficiencies in the laboratory bottle cleaning and sample handling procedures. No contaminants were detected in the trip blanks above the PQL.

One source blank was collected during this sampling event, consisting of sample bottles filled with the distilled water used for decontamination and equipment rinsate blanks. The source blank was used to evaluate the influence of ambient conditions or sample containers on the analytical results. No contaminants were detected in the source blank at concentrations above the PQL.

4.0 DATA VERIFICATION AND VALIDATION

The purpose of data verification and validation is to assure that the data collected meet the data quality objectives (DQOs) outlined in the Quality Assurance Project Plan of the Groundwater Monitoring Plan (Ebasco, 1993c). The process is intended to ensure that the data are of sufficient quality for use in meeting the objectives outlined in the Groundwater Monitoring Plan.

4.1 Data Verification

All data collected were subjected to data verification. In general, verification identifies non-technical errors in the data package that can be corrected (e.g., typographical errors). Data verification included proofreading and editing hard-copy data reports to assure that data correctly represent the analytical measurement. Data verification also included verifying that the sample identifiers on laboratory reports (hard copy) matched those on the chain-of-custody record.

4.2 Data Validation

Data validation was performed by an independent subcontractor, Laboratory Data Consultants, Inc., Carlsbad, CA (LDC). One hundred percent of all data analyzed by a fixed-base analytical laboratory (APCL) were validated. Ninety percent of the data were subjected to Level III and ten percent of the data were subjected to Level IV quality assurance requirements of the Navy (Navy, 1996 and Navy, 1999). The data were further evaluated to help ensure suitability and usability for the purpose of the groundwater monitoring report.

Data validation is a systematic process that is used to interpret, define, and document analytical data quality and determine whether the data quality is sufficient to support the intended use(s) of the data. Validation of a data package includes reconstruction of sample preparation, analysis of the raw data, reconciliation of the raw data with the reduced results, identification of data anomalies, and qualification of data to identify data usability limitations.

4.3 Data Validation Qualifiers

Analytical data were qualified based on data validation reviews. For chemical data, qualifiers were assigned in accordance with the applicable USEPA National Functional Guidelines for Data Validation (EPA, 1994a and 1994b). Individual laboratory data flags can be found in Appendix D. No data were rejected for non-compliance with method requirements during the course of validation.

5.0 WATER LEVEL MEASUREMENTS

Water level measurements were recorded before the sampling event on January 27 and 28, 2003, and after the sampling event on February 26, 2003, to evaluate groundwater flow directions and gradients beneath and adjacent to JPL. Water levels in the shallow wells were measured using a Solinst® water level meter. In the deep multi-port wells, the hydraulic head at each sampling port was measured with a Westbay pressure-transducer probe.

Water table elevation measurements taken before sampling are provided in Table 5-1 and have been contoured in Figure 5-1. Water table elevation measurements taken after sampling are provided in Table 5-2 and have been contoured in Figure 5-2. The hydraulic heads measured at each deep multi-port well screen before and after sampling are presented graphically in Figure 5-3. The pressure-profile records for the deep wells are included in Appendix B.

Water levels in the shallow wells rose from roughly 3.9 to 30.2 feet during the January - February 2003 event, rising an average of about 14 feet. This increase was more significant than the increases measured in Westbay wells screened in Aquifer Layer 1, which averaged about 7.8 feet and ranged from roughly 4.8 to 11.8 feet. Hydraulic head elevations in Westbay wells screened in Aquifer Layer 2 ranged from almost 5.2 feet to 8.9 feet with an average increase of about 7.2 feet, while those screened in Aquifer Layer 3 ranged from about 4.2 feet to 8.1 feet and averaged over 6.8 feet. No notable increases in hydraulic head was measured during the January - February 2003 event, as shown in Figure 5-3. The only well screen in Aquifer Layer 4 (MW-20 Screen 5) rose 6.11 feet during this event.

Water level fluctuations can result from a wide variety of hydrologic phenomena; some natural and some induced by man. It is likely that several of these phenomena are operating simultaneously including, but not limited to:

- Groundwater recharge/infiltration to the water table,
- Air entrapment during groundwater recharge,
- Groundwater pumpage, and/or
- Artificial recharge from the spreading grounds.

As depicted in Figures 5-1 and 5-2, the estimated groundwater flow direction both before and after sampling was generally consistent with previous observations. The flow was primarily to the south-southwest through the eastern portion of JPL and to the east-southeast in the southwest portion of JPL, Arroyo, and plain. The estimated groundwater gradients measured both at the beginning and end of the event ranged from about 0.2 feet per foot near MW-9, at the northern end of the Arroyo, to 0.005 feet per foot across the Arroyo and plain.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions are based upon interpretation of analytical data and field measurements collected during the January-February 2003 event and previous events of the JPL Monitoring Program:

- The chemical plumes beneath JPL are adequately defined and relatively stable. The concentration contour maps generally indicate slow migration of the contaminant plumes over the last year. Comparison of the results with the previous monitoring events did not reveal any significant increases or decreases in contaminant concentrations, with the exception of perchlorate, discussed below. In summary, the January-February 2003 analytical results indicate the following:
  - Four VOCs (carbon tetrachloride, trichloroethene, tetrachloroethene, and 1,1-dichloroethene) were detected in one or more monitoring wells at concentrations above the State or Federal MCLs for drinking water.
  - Perchlorate concentrations exceeded the State IAL for drinking water in six on-facility wells. The highest levels of perchlorate were reported in samples from MW-7, MW-17, and MW-24. Perchlorate concentrations have generally risen over the last two years in these three wells, which are the farthest upgradient, suggesting that the source is nearby or to the north.
  - Total chromium was detected in twenty wells, with concentrations at one on-facility well exceeding the State and Federal MCL. Hexavalent chromium was detected in two wells. At this time, neither State nor Federal regulatory agencies have established MCLs for hexavalent chromium.
- Moderate increases in hydraulic head were measured during this event in all Westbay well screens (Aquifer Layers 1, 2, 3, and 4), while significant increases were measured in shallow wells MW-1, MW-9, and MW-15 in the northeastern corner of JPL facility. The water level fluctuations are likely due to several hydrologic phenomena operating simultaneously including, but not limited to, groundwater recharge, pumpage, and/or artificial recharge.
- Groundwater gradient maps prepared using the January-February 2003 water level measurements indicate that groundwater gradients and flow directions are generally consistent with previous observations (SOTA, 2002 and Foster Wheeler, 2000).

7.0 REFERENCES

California Regional Water Quality Control Board, Central Valley Region. A Compilation of Water Quality Goals. August 2000.

California Department of Health Services. Drinking Water Action Levels. February 13, 2001.

California Department of Health Services Drinking Water Program. California Drinking Water Data. March 8, 2002.

EPA, 1991. Management of Investigation-Derived Wastes During Site Inspections: USEPA Office of Research and Development: EPA/540/G-91/009, May 1991, 35 pp.

EPA, 1992. Guide to Management of Investigation-Derived Wastes: USEPA Office of Solid Wastes and Emergency Response, Publication: 9345.3-03FS, April 1992.

EPA, 1994a. Laboratory Data Validation Functional Guidelines for Evaluating Organics Analysis. February 1994.

EPA, 1994b. Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analysis. February 1994.

Ebasco, 1993a. Work Plan for Performing a Remedial Investigation/Feasibility Study, National Aeronautics and Space Administration Jet Propulsion Laboratory. Pasadena, California December 1993.

Ebasco, 1993b. Field Sampling and Analysis Plan for Performing a Remedial Investigation at Operable Unit 1: On-Site Groundwater. National Aeronautics and Space Administration Jet Propulsion Laboratory. Pasadena, California. December 1993.

Ebasco, 1993c. Quality Assurance Program for Performing a Remedial Investigation for the National Aeronautics and Space Administration Jet Propulsion Laboratory. Pasadena, California. December 1993.

Ebasco, 1994. Field Sampling and Analysis Plan for Performing a Remedial Investigation at Operable Unit 3: Off-Site Groundwater. National Aeronautics and Space Administration Jet Propulsion Laboratory. Pasadena, California. May 1994.

Foster Wheeler, 2000. Report Quarterly Groundwater Monitoring Results. July-August 2000.

Freeze, A. R., and Cherry, J. A., 1979. Groundwater. Prentice Hall, Englewood Cliffs, New Jersey, 604 pp.

Navy Installation Restoration Chemical Data Quality Manual (IR CDQM), Naval Facilities Engineering Service Center (NFESC). September, 1999.

Navy Installation Restoration Laboratory Quality Assurance Guide, NFESC, 1996.

SOTA Environmental Technology. Quarterly Groundwater Monitoring Report, October 2002, National Aeronautics and Space Administration, Jet Propulsion Laboratory Pasadena, California. January, 2001.